

# Strong-coupling diffusion in relativistic systems

Georg Wolschin <sup>a</sup>

<sup>a</sup>*Heidelberg University*

---

*Presented by:* G. Wolschin

---

---

## Abstract

Phase-transition scenarios to a quark-gluon phase are based on the assumption that at least a substantial part of the system thermalizes [1]. In this work, the equilibration in the system of participant baryons is investigated analytically in a relativistic diffusion model (RDM) from SIS via AGS to SPS energies [2]. A prediction for RHIC proton rapidity distributions demonstrates the nonequilibrium behaviour of the baryonic system at higher energies.

A very general description of relaxation processes in nonequilibrium systems is provided by the Fokker-Planck equation (FPE) [3]. If applied to Lorentz-invariant observables such as the rapidity, the approach is suitable at relativistic energies [4]. In particular, it has been shown that proton rapidity distributions can be represented on the basis of a linear Fokker-Planck equation as outlined in the RDM [2].

In a weak-coupling situation (where the duration of a single interaction is smaller than the time between two subsequent collisions), the transport coefficients are related to each other through the temperature  $T_p$  of the thermal equilibrium distribution. I have derived [2] the corresponding weak-coupling dissipation-fluctuation theorem (Einstein relation), and compared it to experimental proton rapidity spectra from SIS to SPS energies. The relations are fulfilled at low SIS-energies [5], whereas progressively larger deviations rising to an order of magnitude are found at AGS- and SPS-energies.

This effect is investigated [6] as a consequence of the strong-coupling character of the system which is clearly evident at SPS-energies and beyond. The rapidity diffusion coefficient becomes time-dependent, and by far exceeds the weak-coupling value at short times. The corresponding FPE is solved analytically. With empirical values for the strong-coupling rapidity diffusion coefficient, predictions for the 40 A GeV/c SPS, and 2\*100 A GeV/c RHIC results are made. At RHIC energies, the proton rapidity distribution shows two clearly separated peaks indicating that the system of participant baryons - no matter whether it passes through a deconfined phase or not - does not reach statistical equilibrium. Hence, the successful appli-

cation of thermodynamical concepts to hadron production does not imply that the baryonic system has actually reached statistical equilibrium.

- [1] Proc. Quark Matter 1999, Torino, Nucl. Phys. A 661 (1999).
  - [2] G. Wolschin, Eur. Phys. J. A 5 (1999) 85; Europhys. Lett. 47 (1999) 30.
  - [3] N.G. van Kampen, Phys. Bl. 53 (1997) 1012.
  - [4] G. Wolschin, Z. Phys. A 355 (1996) 301.
  - [5] B. Hong et al., Phys. Rev. C 57 (1998) 244.
  - [6] G. Wolschin, preprint (2000).
-